EUTROPHICATION AND WATER QUALITY

Iwona Wagner-Lotkowska

Department of Applied Ecology, University of Lodz

CAUSES OF WATER QUALITY DEGRADATION

URBANIZATION

- discharge of municipal sewage;
- storm runoff of toxic substances.

INDUSTRY *(Mining, Power plant, Refinery, Metallurgy, Pharmacy, Chemical, Textile, Food industry)*

- discharge of toxic and hazardous substances (i.e., POPs and PIPs);
- discharge of hot water;

AGRICULTURE *(Animal farm, Large fish farm, Natural fertilizers, Artificial fertilizers, Pesticides)*

- disposal and leaching of manure from farms;
- leaching of fertilizers and pesticides to ground and fresh waters;
- outflow from aquaculture farms;
- land erosion;
- increase of soil salinity through evapotranspiration, drainage;

TYPES OF POLLUTION

URBANIZATION

INDUSTRY

AGRICULTURE

Toxic and organic pollution

physical pollution

(nutrient enrichment)
eutrophication

WHAT IS EUTROPHICATION

- is a natural process occurring in surface aquatic ecosystems as they age.
- is the result of processes associated with enrichment of aquatic ecosystems with nutrients, mainly phosphorus and nitrogen but also carbon, silicon, potassium, calcium, iron, and manganium.
- recently has been accelerated due to increasing anthropogenic activity in catchments.

Fot. M. Tarczyńska, 1999

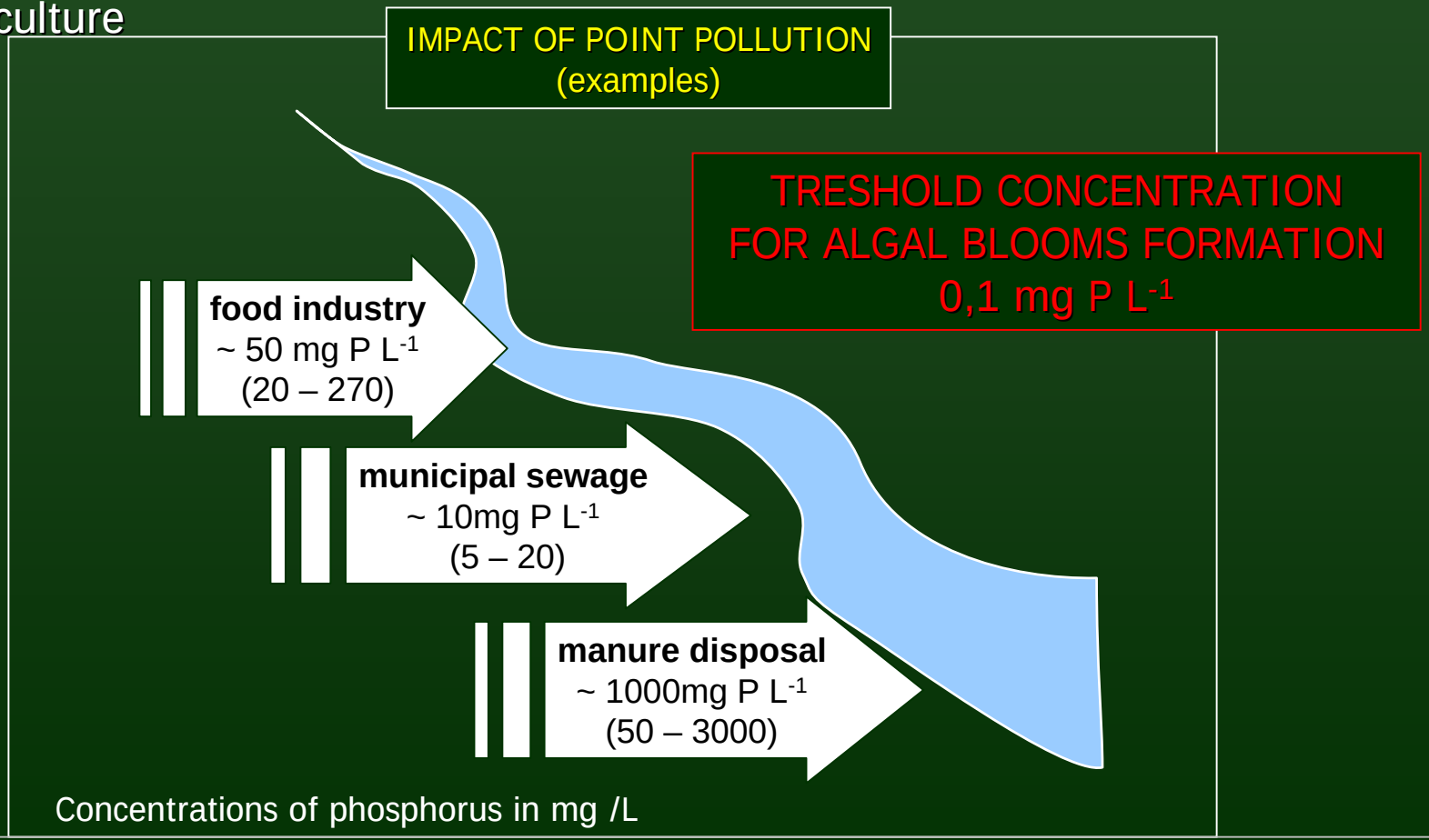
Department of Applied Ecology University of Lodz
International Centre for Ecology Polish Academy of Sciences, Lodz

Point sources of pollution

CAUSES OF EUTROPHICATION

- ✓ Municipal sewage
- ✓ Storm water
- ✓ Industry
- ✓ Agriculture

✓ Control by complementing technological approaches with ESTsc

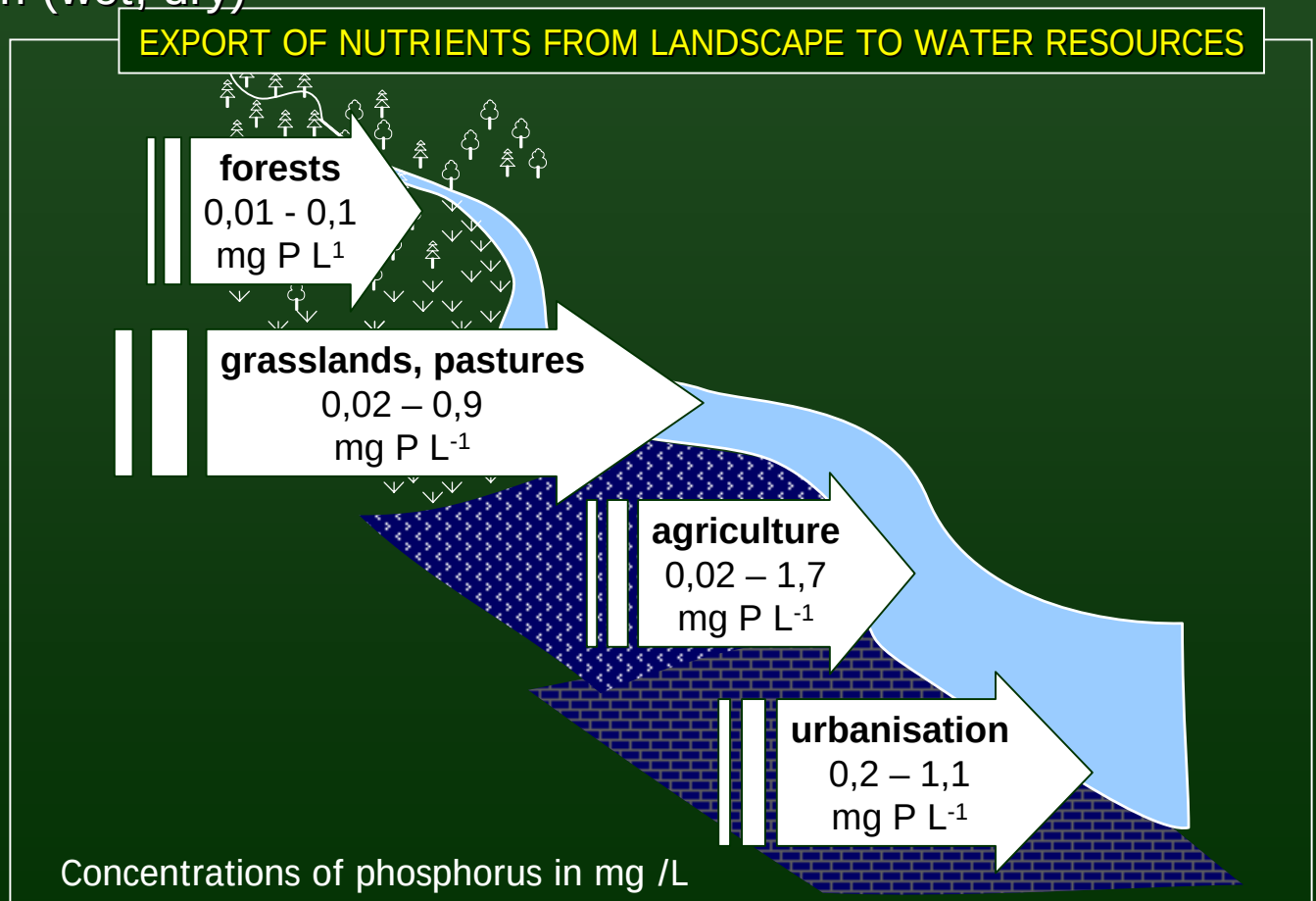


Non-point sources of pollution

CAUSES OF EUTROPHICATION

- ✓ Agriculture surface and subsurface runoff
- ✓ Storm-runoff
- ✓ Precipitation (wet, dry)

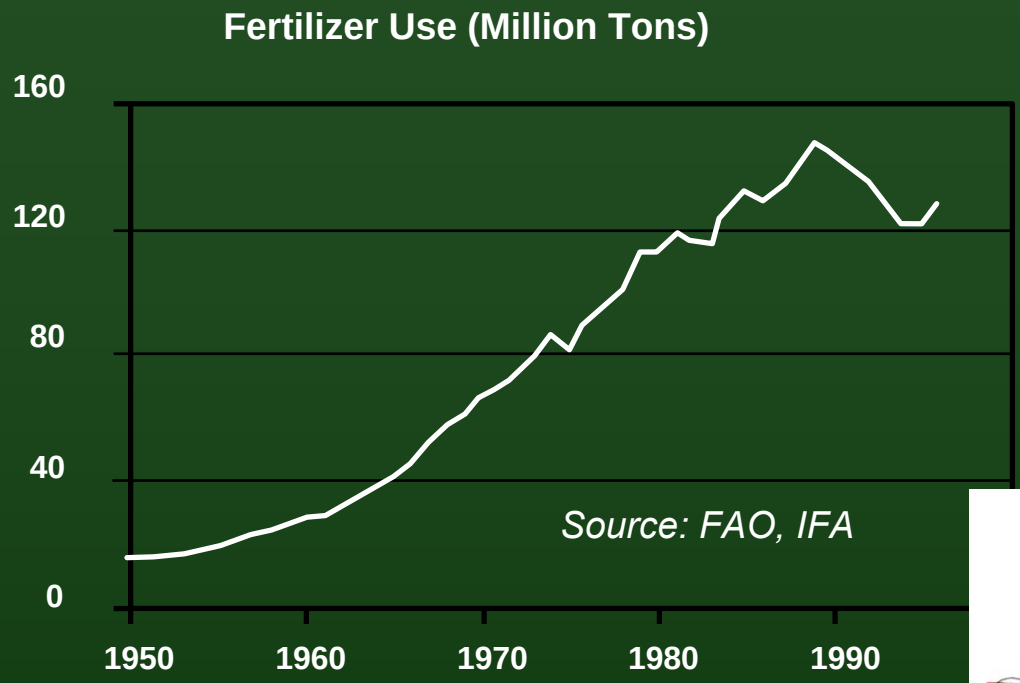
✓ Control by complementing technological approaches with ESTs

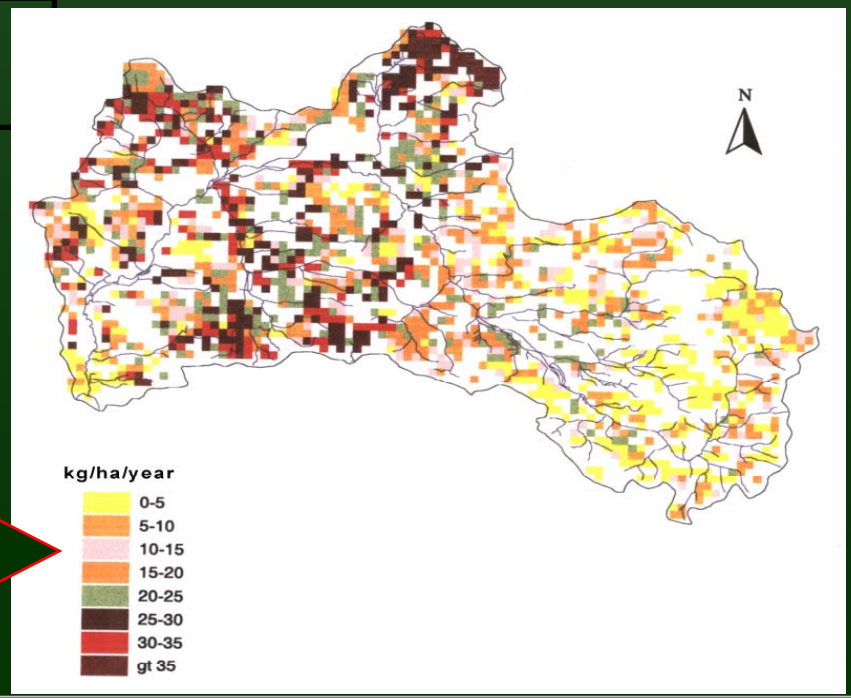


Department of Applied Ecology University of Lodz
International Centre for Ecology Polish Academy of Sciences, Lodz

Non-point sources of pollution

CAUSES OF EUTROPHICATION





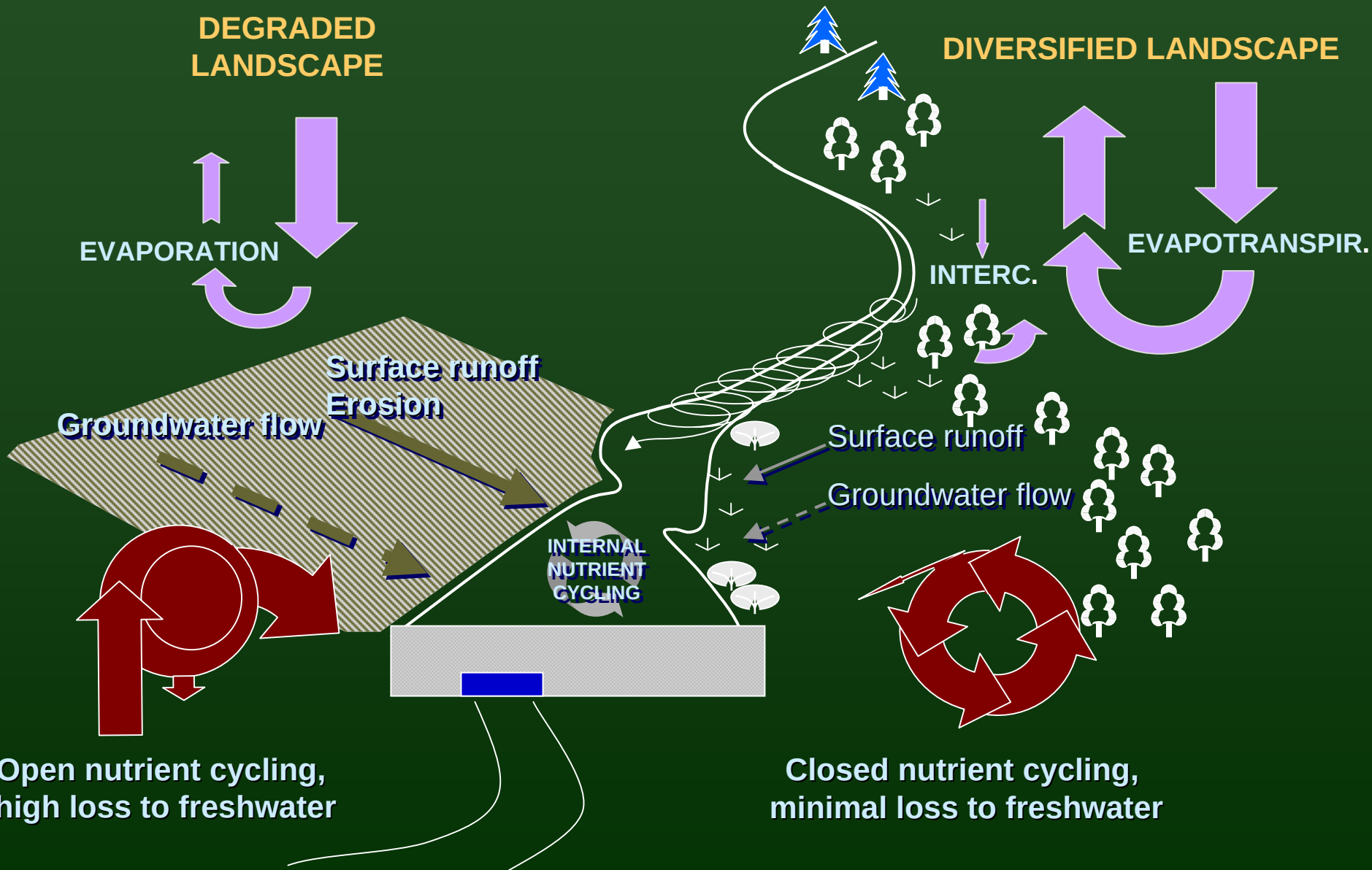
Potential nitrogen transport to groundwater
(long term scenario – 3 years)

Department of Applied Ecology University of Lodz
International Centre for Ecology Polish Academy of Sciences, Lodz

(Bis, et al.., 2000)

DEGRADATION OF NATURAL CYCLES IN A CATCHMENT RESULTING IN EUTROPHICATION

CAUSES OF EUTROPHICATION



Department of Applied Ecology University of Lodz
International Centre for Ecology Polish Academy of Sciences, Lodz

(Zalewski, 2000)

CHARACTERISTICS OF EUTROPHICATION

Eutrophication of water bodies can be classified by:

- ✓ phosphorus concentrations,
- ✓ phytoplankton biomass,
- ✓ chlorophyll a concentrations,
- ✓ Secchi disk visibility.

ultra-oligotrophic → oligotrophic → mesotrophic → eutrophic → hypereutrophic

- ✓ low nutrient inputs
- ✓ low primary productivity
- ✓ high transparency
- ✓ a diverse biota

- high nutrient inputs ✓
- high primary productivity ✓
- low transparency ✓
- high biomass of fewer species ✓

(with a greater proportion of cyanobacteria in long retention waters)

Department of Applied Ecology University of Lodz
International Centre for Ecology Polish Academy of Sciences, Lodz

EFFECTS OF EUTROPHICATION

✓ Increased growth of algae and cyanobacteria

Microcystis aeruginosa Kutz.

IN THE WORLD

- **90% of Microcystis blooms**
- **20% of Aphanizomenon blooms**

are toxic

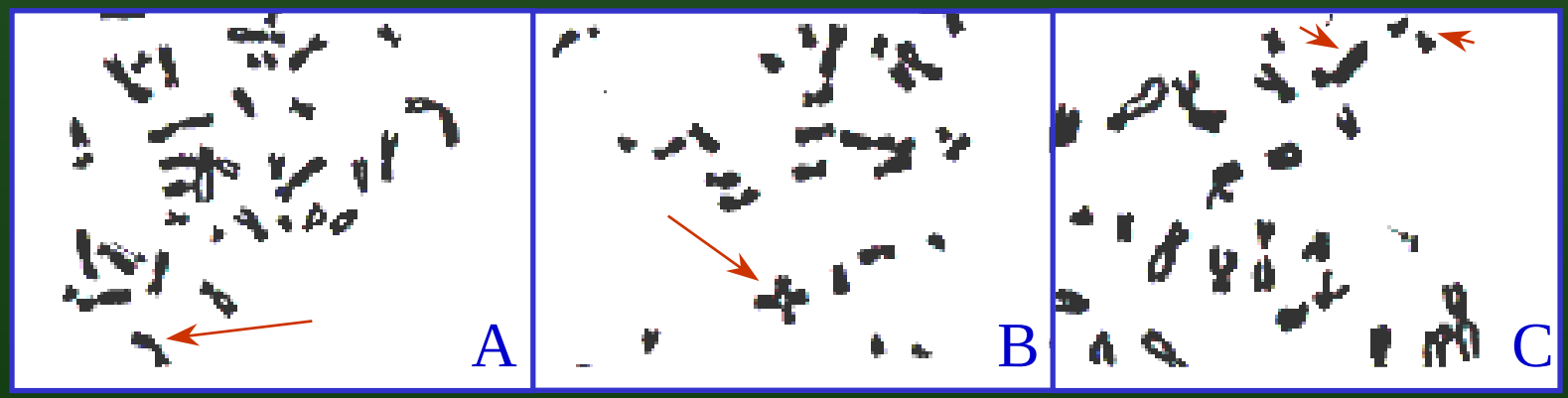
Department of Applied Ecology University of Lodz
International Centre for Ecology Polish Academy of Sciences, Lodz

EFFECTS OF EUTROPHICATION

CHROMOSOMAL ABERRATION INDUCED BY EXTRACT FROM CYANOBACTERIAL BLOOM

in *in vitro* human lymphocytes

A - chromatid breaks, B - chromatid exchanges, C- dicentric chromosome and acentric fragment.



(Osiecka, Zalewski, Tarczyńska, 1996)

Mikrocystyn-LR

•caused massive mortality among wild and domestic animals and human (e.g. 50 patients died in hemodialisis center in Brazil,1996)

• carcinogens of tumour-promoting effect, can lead to the primary liver cancer

Mikrocystyn-LR is a stronger poison than:

• strychnine (x 10)

• sodium cyanide (x 200)

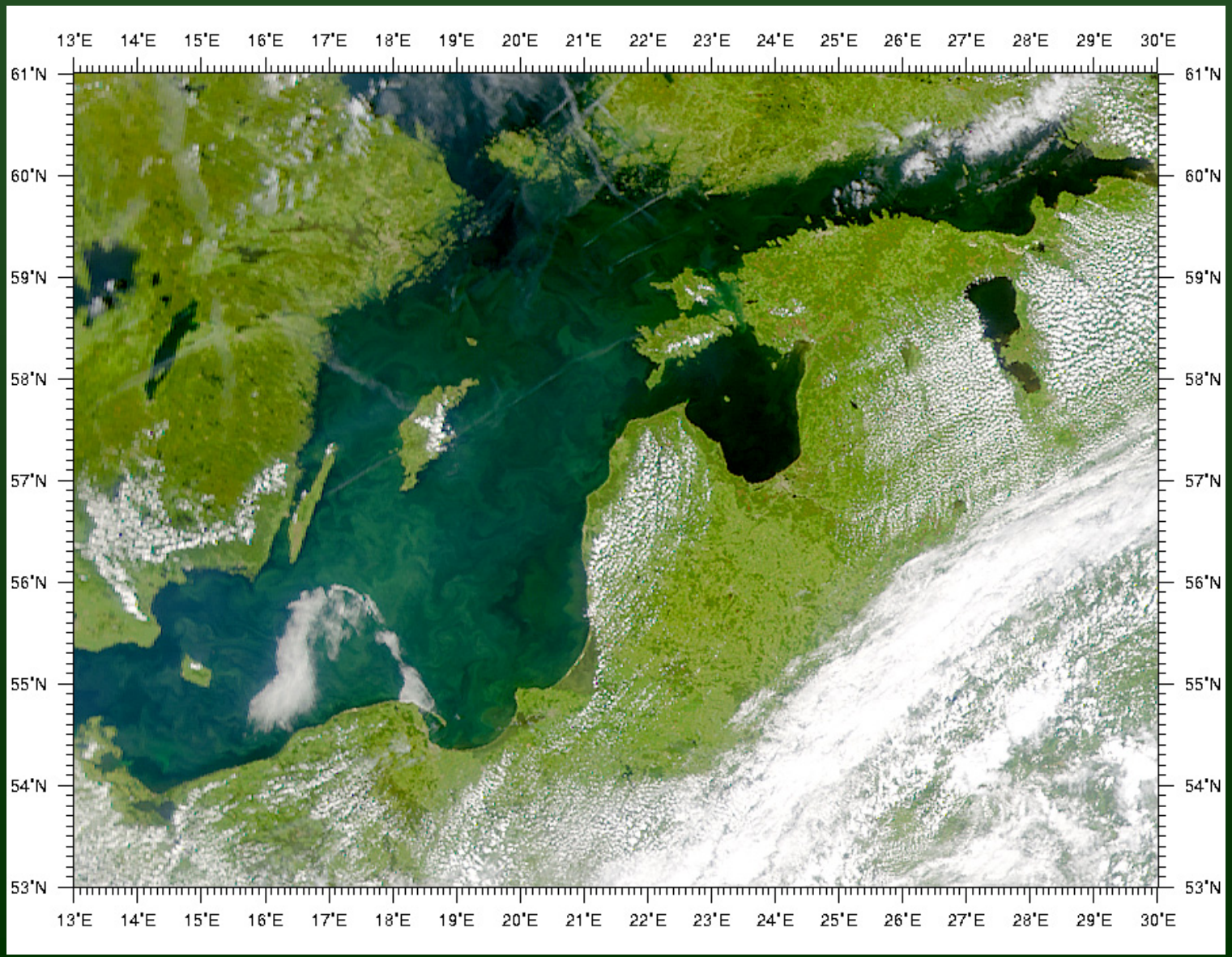
• 2,3,7,8 -TCDD - dioxins (2-12 x)

LD 50 for mouse, injection (EPA 1985, Kotak 1993)

Department of Applied Ecology University of Lodz
International Centre for Ecology Polish Academy of Sciences, Lodz

EFFECTS OF EUTROPHICATION

EUTROPHICATION OF THE BALTIC SEA



OTHER EFFECTS OF EUTROPHICATION

Phytoplankton blooms can degrade water quality in several ways: decrease water column transparency, affect water taste and odour, lead to depletion of oxygen concentration, change fish community composition, decrease abundance of submerged macrophytes, cause a health hazard to people and animals by production of toxic compound

- ✓ Growth of Aquatic Plants
- ✓ Turbid waters noxious odours and poor tasting water
- ✓ Anoxia and fish kills
- ✓ Species Changes
- ✓ Massive expansion of certain aquatic plants and reduction of biodiversity
- ✓ Elevated Nitrate Concentrations
- ✓ Increased Incidence of Water-related Diseases

OTHER EFFECTS OF EUTROPHICATION

- ✓ Massive growth of aquatic plants
- ✓ Species Changes and reduction of biodiversity

- water hyacinth (*Eichhornia crassipes*),
- aquatic fern (*Salvinia molesta*)
- Nile cabbage (*Pistia stratiotes*)

- can cover large areas near-shore and can float into open water;
- blocks light for submerged vascular plants and phytoplankton;
- often produce large quantities of organic detritus (anoxia and emission of methane and hydrogen sulphide);
- can restrict fishing and recreational uses of water bodies;
- can block irrigation and navigation channels and intakes of hydroelectric power plants.

OTHER EFFECTS OF EUTROPHICATION

- ✓ Turbid waters noxious odours and poor tasting water
- ✓ Anoxia and fish kills

Increased concentrations of allochtonous suspended solids and humic acids may decrease water transparency.

Increased trophy enhances generation of autochthonous organic matter. As it decomposes in the water column or in the sediments, the concentration of dissolved oxygen decreases.

In shallow lakes and where plant production is large, complete deoxygenation of the sediments and water can occur, causing fish kills and affecting aquatic life.

Anoxic conditions can facilitate release of ammonia, iron, manganese and hydrogen sulphide concentrations posing risk to biota and human health.

In addition, phosphate and ammonium may be released into the water from anoxic sediments, further enriching the lake.

OTHER EFFECTS OF EUTROPHICATION

- ✓ Health hazards due to elevated nitrate concentrations
- ✓ Increased Incidence of Water-related Diseases

Elevated Nitrate Concentrations

• High concentrations of nitrate (above 10 mg per litre) in drinking water, can cause health problems, such as the inhibition of the ability of infants to incorporate oxygen into their blood and can result in a life threatening condition called blue baby syndrome (methylhaemoglobinaemia).

Increased Incidence of Water-related Diseases

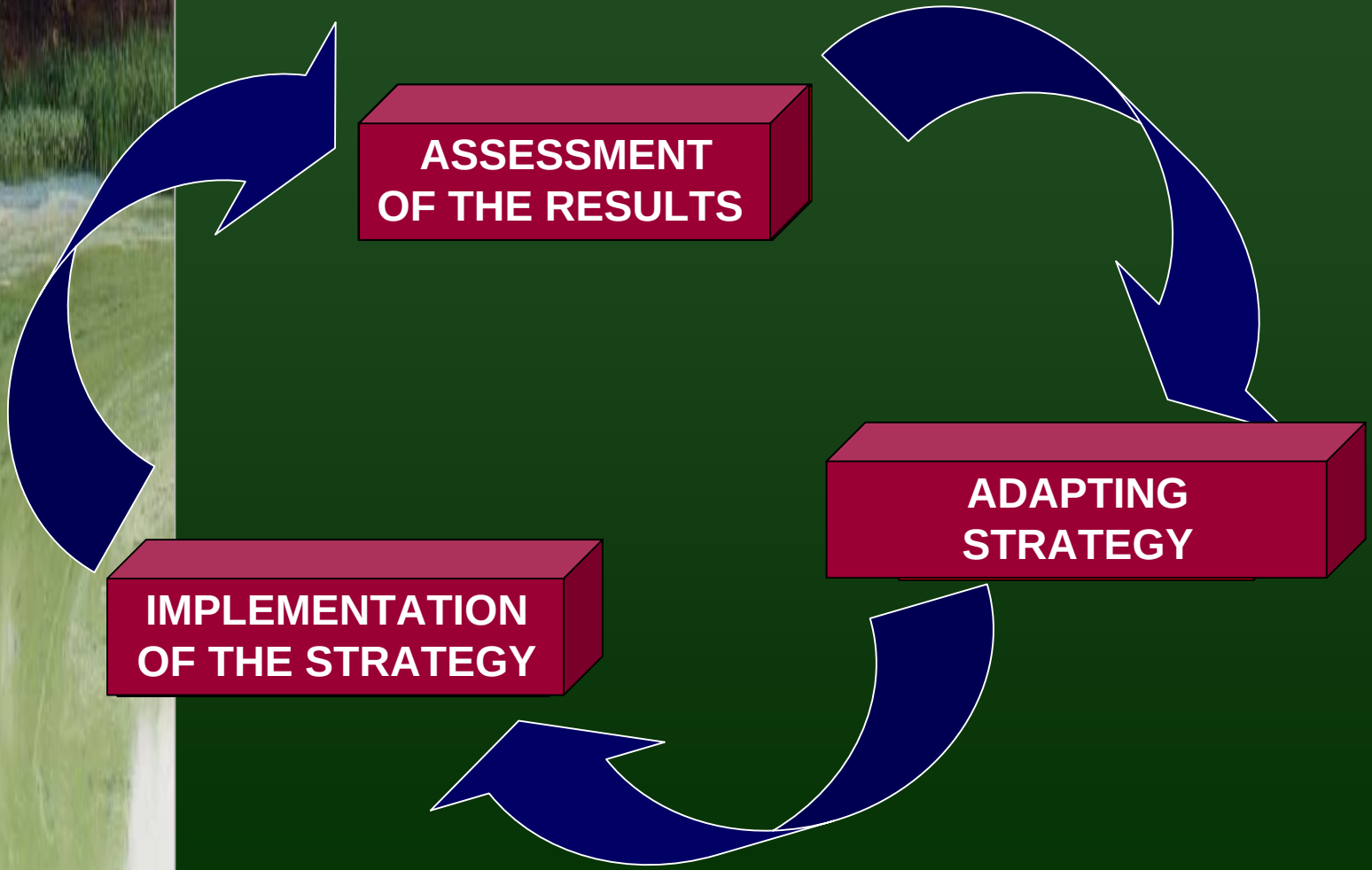
• Eutrophication resulted from untreated human sewage may facilitate spread of human diseases. Municipal water supplies that pipe water throughout a city from central storage reservoirs are highly susceptible to spread of diseases, such as typhoid or cholera, that can be seeded by seemingly negligible faecal pollution from infected persons.

Strategies for Eutrophication management

A successful strategy will require several approaches

- ✓ Application of a combination of technologies.
- ✓ Prevention instead of correction, as ecosystem restoration.
- ✓ Knowledge of the ecosystem characteristics and functioning.

Adaptive Assessment Management for eutrophication management



Department of Applied Ecology University of Lodz
International Centre for Ecology Polish Academy of Sciences, Lodz

1. ASSESSMENT OF THE PROBLEM

Fundamental parameters to be assessed

- ✓ Intensity of the human impact
- ✓ Absorbing capacity of ecosystem (resistance to change and resilience, in response to anthropogenic impacts)

1. ASSESSMENT OF THE PROBLEM

Fundamental parameters to be assessed

✓ Intensity of the human impact

Assessment of major past, ongoing
and planned activities
in a catchment.

APPROACH

SCREENING
identification of hot spots
(e.g., by map studies & questionnaires)

DIRECT ASSESSMENT OF IMPACTS
(e.g., experiments, field studies, laboratory assessment)

QUANTIFICATION OF PROBLEMS
(monitoring)

(UNEP, 2004)

1. ASSESSMENT OF THE PROBLEM

Fundamental parameters to be assessed

✓ Absorbing capacity of the ecosystem (resistance to change and resilience, in response to anthropogenic impacts)

Absorbing capacity of ecosystems against human impact, usually decreases with their degradation

2. IMPLEMENTATION

CONTROL OF EUTROPHICATION

Reduction of nutrient supply

reduction of external
point and non-point pollution

Changing nutrient pathways
by ESTs application

conversion of nutrients:
- from inorganic to organic forms
- transfer from dynamic
  to unavailable pool
- reduction of internal loading

(Zalewski, 2000)

Phytotechnology in eutrophication management

How to change nutrient pathways?

- ✓ Improvement of the structure of landscape (e.g. aforestation, reforestation, landscape patchiness);

✓ LANDSCAPE

- ✓ Reduction of nutrients supply by application of constructed and natural wetlands;
- ✓ Restoration and management of land/water ecotones;
- ✓ Restoration of rivers' floodplains;

✓ LAND/WATER TRANSITION ZONES

- ✓ Inactivation of phosphorus in sediments (e.g. by restoration of littoral and bottom vegetation);
- ✓ Restoration of rivers' structure (e.g. re-meandering, introduction of bottom and littoral vegetation);

✓ WATER COLUMN AND SEDIMENTS

Eutrophication control and economy....

Eutrophication can detrimentally affect a range of activities that involve the direct or indirect use of water, such as:

- ✓ restriction of drinking water extraction or increase costs of water purification;
- ✓ fish-kills, lowering fish yields and biodiversity (limiting factor for fisheries and food production), although in some cases it may increase productivity;
- ✓ health hazards and lowering quality of life;
- ✓ restriction of recreational uses of waters;
- ✓ problems in hydropower infrastructure operation.

Eutrophication control and economy....

Application of EST may have a positive effect on environment and economy, by:

✓ providing cost effective measures for reduction of threats, by e.g., complementing technological sewage treatment with ESTs, reducing non-point sources of pollution, providing measures mitigating effects of land use degradation and overexploitation;

✓ providing opportunities for the regional economy, by converting of the potential threats into opportunities for development of new markets, providing labour, reducing outflow of capital;